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SILICA EXPOSURE IN CONSTRUCTION WORKERS

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SILICA EXPOSURE IN CONSTRUCTION WORKERS

by

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Abstract

This paper discusses the issues, objectives, methods, results and conclusion of how to control/reduce the respirable crystalline silica exposure to construction workers in the organization hereafter referred to as the "Company." This evaluation will be achieved by assessing the following occupational exposure tools: literature review, work practices, engineering controls and personal protective equipment (PPE) on exposures to silica during construction activities. The construction activities observed, studied, researched and sampled include concrete sawing, concrete cutting and application, and dry/wet sanding drywall mud.

High construction tasks, for example, produce respirable dusts often containing crystalline silica. Such tasks include concrete saw cutting and concrete core drilling. Even in interior construction efforts, such activities as drywall finishing, which involve dry and wet sanding and applying, can increase the rate of exposure to crystalline silica.

After reviewing the sampling results and the conclusions of the literary review articles, findings show it is possible for workers to reduce exposures to silica during the construction activities discussed in this study, through work practices, engineering controls and PPE. The long-term benefit of upfront adoption of the work practices, engineering controls and PPE is consistent with the conservative approach the Company embraced regarding the safety and well-being of its workers, and may possibly prevent future cases of over-exposure to silica.

Keywords:

Crystalline silica, Respirable Dust, Exposure, Construction, Wet Methods, Dry Methods

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Glossary of Acronyms

Acronym	**Meaning**
ACGIH	American Conference of Governmental Industrial Hygienists
APF	Assigned Protection Factor
$C_{Silica\ [Quartz]}$	Concentration of Silica [Quartz] collected on sample filter
D_{50}	Particle diameter corresponding to 50% sampling efficiency
ECP	Exposure Control Plan
GM	Geometric Mean
GSD	Geometric Standard Deviation
MAC	Maximum Allowable Concentration
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
RCSQ	Respirable Crystalline Silica Dust (Quartz)
RSP	Respirable Suspended Particulate
TLV	Threshold Limit Value
TWA	Time Weighted Average

1. Introduction

Construction workers are at higher risk for silicosis due to exposure to high levels of respirable crystalline silica. This respirable dust can reach the alveolar region of the lungs and have the potential to cause serious disease to those who are exposed. Such serious diseases are lung disease, lung cancer, silicosis, as well as other system illnesses. Therefore, recommendations for engineering controls, respiratory protection and work practices must be in place in order to prevent such incidents from happening.

The most common type of crystalline silica is quartz. Quartz accounts for nearly 12% by volume of earth’s crust and is the second most common type of surface material (Occupational Safety and Health Administration [OSHA], 2009). Quartz exists within numerous materials such as mortar, brick, concrete, dimensional stone, slate, tile, stone aggregate, and sand utilized for blasting. Other kinds of construction materials that also contain crystalline silica are roofing granules, asphalt filler, soils, plastic composites, and to a lesser level, paint, plaster, putty, caulking, and some wallboard joint compounds. Other than quartz, cristobalite also exists in several high-temperature exposed places like some ceramic tiles, brick lining of vessels and boilers, and even volcanic ash.

Such common occurrences of quartz demand construction workers take precautions when performing certain tasks. Exposure to crystalline silica can occur in many construction activities, including: chipping, hammering, and drilling in rock or concrete or brick; crushing, loading, hauling, and dumping of rock and concrete; abrasive blasting using silica sand or from the materials being blasted (concrete); sawing, hammering, drilling, grinding, and/or chipping on masonry or concrete; demolition of brick, concrete, or masonry; dry sweeping concrete, sand, or rock dust; trenching and excavation; sheetrock activities, and tile and grout work.

Stacey (2007) examines concentrations of silica and exposure limits. “Internationally, occupational exposure limits (OELs) for respirable crystalline silica range from 0.05 to 0.2 mg/m^3. These OELs are often expressed in terms of an 8-hour, time-weighted average (TWA) and assume the working day is about 8 hours” (Stacey, 2007, p. D-1). Although they identified exposure limits in Europe and the Americas, their conclusions in the end leaned more towards theoretical with no concrete proof of validating a standard exposure limit. This is important to note because people all over the world are uncertain of how much is too much when it comes to silica exposure on construction sites, and identifies a gap in information regarding occupational exposure standards.

Due to company confidentiality policies, the laboratory, where observations and sampling was conducted, shall be referred to as “the Company” in this paper. The company follows the American Conference of Governmental Industrial Hygienists’ (ACGIH) threshold limit value (TLV) for silica, instead of the Occupational Safety and Health Administration’s (OSHA) permissible exposure limits (PEL).

The Company has created a comprehensive safety and industrial hygiene program using best practices, which in most cases goes well beyond regulatory compliance. Ensuring all employees go home safe and healthy is the cornerstone of the program. With the company’s mindset, they have decided to adopt the more conservative ACGIH Silica, Crystalline Quartz (Respirable Fraction) occupational exposure limit (OEL) of 0.025 mg/m^3 over OSHA’s construction PEL of (250 mppcf)/(%SiO_2 +5).

The respiratory tract is divided into three categories, i.e. nasopharyngeal (NP) region, tracheobronchial (TB) region and pulmonary (P) region. When workers are exposed to silica in their breathing zone, the silica particles may be deposited in one of the respiratory tract regions depending on particle size distribution, hygroscopicity, shape, etc. The inhalable fraction represents particles that enter the respiratory system via the nose or mouth (D_{50} = 100 µm). The thoracic fraction is that portion of the inhalable particles that pass the larynx and penetrate into the conducting airways (trachea, bifurcations) and the bronchial region of the lung (D_{50} = 10 µm). The respirable fraction is the portion of inhalable particles that enter the deepest part of the lung, the nonciliated alveoli (D_{50} = 4 µm) and is related to the development of silicosis and other such chronic diseases. D_{50} represents the particle diameter corresponding to 50% sampling efficiency.

The silica concentration within construction materials play important role in increasing or decreasing likelihood of crystalline silica exposure. In addition, factors experienced in the work environment also play a role. These could include semi-enclosed, enclosed, open spaces, and/or multiple operations creating silica dust. Environmental conditions, such as wind speed and direction, can also play a part.

Organizations like OSHA, National Institute for Occupational Safety and Health (NIOSH), and ACGIH encourage employers to conduct intermittent exposure monitoring to confirm work and engineering practice controls remain effective, and to ensure suitable respiratory protection is being utilized when required. Controls continually evolve, such as equipment modification. Construction workers involved in tasks exposed to silica should take precautions, whether it be outdoor or indoor.

Using past studies, observation and air monitoring, this paper will highlight levels of exposure in the multiple settings discussed: concrete saw cutting; concrete core drilling and drywall finishing: applying, dry sanding, and wet sanding.

Such information will help reveal the need to use engineering controls, e.g., ventilation, wet methods, isolation, before using respiratory protection while performing the tasks listed above. It will also show how to develop controls and evaluate exposures to crystalline silica more effectively. The problem is overexposure to silica during construction activities, as well as the solution, lies in creating awareness of how much exposure each activity produces as well as forming effective controls to reduce crystalline silica exposure.

If construction workers are aware of which activities produce high levels of crystalline silica exposure and the kind of precautions needed to prevent breathing such hazardous material, overall exposure rates can diminish. Organizations like OSHA and ACGIH already have safety precautions in place to reduce crystalline silica exposure. This paper focuses on the following construction activities: concrete sawing, concrete cutting and applying, dry/wet sanding drywall mud. In respect to the increased risk to these construction workers, research, observations and sampling have been conducted to help reduce the exposure and risk of the crystalline silica, respirable dust during these activities.

This paper will shed additional light on the problems and possible solutions to overexposures to silica through past studies, observation and air monitoring. It will provide information on successful techniques used to reduce exposure to crystalline silica as well as useful protection equipment in preventing increased exposure. Each section will cover one activity and/or development of identification and implementation.

1.1. Problem

Overexposure to silica during construction activities is an ongoing problem experienced by many construction workers. Numerous construction activities may put workers at risk of inhaling silica-containing dusts, and there is a significant body of literature detailing exposure levels by means of a task-based strategy. Suave et al., (2012) used statistical modeling to examine a data set containing 1466 task-based, individual respirable crystalline silica (RCS) measurements collected from 46 sources to approximate exposure levels for the duration of construction tasks as well as the effects of factors of exposure.

Suave et al. (2012) used the Monte–Carlo simulation to recreate personal exposures from summary limits. The statistical modeling involved multimodal inference “with Tobit models containing combinations of the following exposure variables: sampling year, sampling duration, construction sector, project type, workspace, ventilation, and controls. The model containing all the variables explained 60% of the variability and was identified as the best approximating model” (Sauve et al., 2012, p. 432). From the 27 tasks checked in the data set, masonry chipping, abrasive blasting, scabbling concrete, tunnel boring, and tuckpointing had estimated geometric averages above 0.1mg m^{-3} established on the exposure scenario developed.

When examining activities involving anything that disperses particles readily like tunneling and sawing, crystalline silica was found in higher levels than when no such activities were performed. This is important in order to identify properly which activities are more prone to crystalline silica exposure than others are. Construction workers perform many activities during work hours. Examining their work habits and safety standards established within the workplace may help reduce the problem of overexposure in construction activities. For example, quartz is very common among surface materials especially in construction. Reduction of exposure must be met in the majority of construction activities, even indoor activities like sheet rocking.

1.2. Background

Silica, a naturally occurring mineral in soil and rock, is the second most abundant mineral on the earth’s surface. When inhaled, silica dust can cause cancer, silicosis, and increase the risk of developing Tuberculosis or TB infection. Crystalline silica or airborne silica is present in many industries like mining, foundry work, concrete manufacturing, glass, stone crushing, pottery, painting, and most importantly, construction.

1.2.1. Concrete Saw Cutting

Concrete saw cutting is one of the activities exposing construction workers to crystalline silica. When construction workers cut concrete dry versus wet, exposure levels of crystalline silica are high. Therefore, many believe water spray offers sufficient control to limit worker exposures to levels below the silica PEL (Flanagan, Loewenherz & Kuhn, 2001). Research shows water spray-controlled versus dry or uncontrolled crystalline silica provide a noticeable and significant reduction in terms of dust production. "A NIOSH study found a mean exposure of 0.09 mg/m3 for four wall saw/core drilling exposures. These limited data suggest that water application often, although not always, maintains the silica content below the PEL" (Flanagan, Loewenherz & Kuhn, 2001, p. 1097).

Thorpe (1999) examined and evaluated three dust control systems used with cut-off saws on site: wet dust suppression by means of mains water, local exhaust ventilation, and the same system via water from a transportable water tank. The efficacy of water suppression on cut-off saw usage has been exactly quantified in controlled research laboratory conditions by way of measurements with/without dust control. The average concentrations of airborne crystalline silica were minimized by an element of between three and seven times, the exactness being partial by the comparatively high limit of exposure for silica. Everything in terms of controls systems largely lessened respirable dust levels at least 90%. Efficacy did not depend on blade type. However, "a diamond blade was more effective than a resin-bonded blade with the pressurized water system; cutting a slab with this type of blade could be completed before the water tank required repressurization." (Thorpe, 1999, p. 443).

Wet saw cutting is a major reducer of crystalline silica in concrete cutting. This is because it prevents particles from dispersing into the air of workers' breathing zones utilizing such tools. "Water appears to be effective for reducing concrete core drilling emissions. When the core bit is sunk into the concrete, dust particle velocity is slowed and mixed with water before exiting the borehole, emitting slurry with little velocity to produce an airborne aerosol" (Flanagan, Loewenherz & Kuhn, 2001, p. 1100). When dry cutting, particles are more readily dispersed into the air, resulting in increased exposure. Although respiratory protection may reduce a worker's exposure, it is the last choice in the hierarchy of controls. Respiratory protection only protects the worker wearing it, whereas engineering controls, e.g., using water to perform the cutting, potentially protects everyone in the vicinity of the exposure.

Construction workers in general utilize water frequently when using saws because of the potential reduction in particle dispersal in the air, but also because it makes cutting concrete easier. It is an excellent way to improve the safety of construction workers as well as decrease likelihood of silica exposure when water.

1.2.2. Concrete Core Drilling

Concrete core drilling similar to concrete saw cutting has potentially devastating effects to one's health if drilling dry. A 2002 study assessed the efficacy of "commercially available local exhaust ventilation (LEV) systems for controlling respirable dust and crystalline silica exposures during concrete cutting and grinding activities" (Croteau, Guffey, Flanagan & Seixas, 2002, p. 458). Union-sponsored apprentices performed work activities including tuck-point grinding, brick cutting, surface grinding, paver block, and concrete block cutting with hand-held saws. Three ventilation rates: 0, 30, and 75 cfm, were tested for every tool. Ventilation treatments were replicated three times all in random order during nine 15-minute work sessions per participant. The results showed major reduction in silica or respirable dust exposure, with the exception of the hand-held saw. Average exposure levels for 75 cfm treatments had lower rates of exposure than the 30 cfm treatments. Although exposure decrease was noteworthy (70-90% low ventilation rate, 80-95% reduction high ventilation rate), individual respirable dust exposures remained very high.

This study is important to note because while wet drilling and sawing methods can be useful in reducing individual silica exposure, ventilation efforts may not be as effective. Concrete core drilling is often done dry as seen in various construction projects throughout the world. This can be extremely hazardous because of the amount of silica drilling disperses to an individual drilling. Construction workers may opt for dry drilling because it is less expensive and requires less clean up than wet drilling. However, latest research shows improvements in wet drilling with micro-Nano-based drilling fluid (Mao et al., 2015, p. 90). This is because researchers claim micro-Nano composite materials have excellent potential for creating intelligent drilling fluid. “The results showed that the composite, as a micro-nano drilling fluid additive, possessed excellent properties such as thermal stability, rheology, fluid loss and lubricity. Especially, it could plug the formation effectively and improve the pressure bearing capability of formation significantly” (Mao et al., 2015, p. 90).

1.2.3. Sheetrock Finishing

Construction jobs often include sheetrock finishing. Sanding and finishing sheetrock joint compound can be a dusty construction action. Simmons, Jones & Boelter (2011) studied potential factors that may influence exposure to respirable as well as total dust for bystanders and sanders within the space of sheetrock joint compound finishing. They observed 17 test events in a room-scale isolation chamber. The researchers found air change rate to negatively correlate with respirable dust TWA concentration (C_{twa}) both in the sander's personal breathing zone and surrounding area. They could not conclude specific sanding tool types systematically influences dust C_{twa}, but the use of 80-grit abrasive was associated with the highest dust C_{twa} (Simmons et al., 2011, p. 332). They also found respirable dusts uniformly dispersed 1–8.2 m away from sanding activities in a fixed location. Both total and respirable dust C_{twa} found in the sander's personal inhalation zone are greater than in the nearby area. The respirable portion of the whole dust mass C_{twa} was more in the adjacent area than in what was in the sander's personal inhalation zone. The concentrations of respirable dust measured increased over the period of sanding, showing a temporal trend similar to what was predicted. An interesting thing to note form the article was dust concentrations resumed to pre-activity or background levels 2 to 4 hours after termination of the sanding activity.

This means while there is an increase in dust when sanding sheetrock, the overall amount of dust after will dissipate in a relatively short period. However, the information also suggests the dust can affect not just the sander but also bystanders. Safety measures must take into consideration the amount of dust dispersed within the primary work area as well several feet away.

1.2.3.1. Sheetrock Joint Compound Application

Reducing exposure to silica and other dust particles can be particularly difficult during application of joint compound to sheetrock. Sanding of the joint compound can involve a major dispersal of dust particles into the air. Even after the sanding is completed, the particles can stay in the air for up to four hours. This means any construction workers working on or near the area that is finishing sheetrock may potentially be exposed to dust particles, including silica, for several hours.

Any exposure to silica can be hazardous, but over time, it can prove deadly. There are two types of applications when it comes to sheetrock finishing: dry sanding and wet sanding. Dry sanding with a block sander causes the more particle dispersal and increases chances of greater crystalline silica exposure verses wet methods (Young-Corbett and Nussbaum 2009). Wet methods are often the most effective means of controlling dust, because particles never have a chance to become airborne. Drywall compound manufacturers often recommend using wet finishing methods for dust control. (Mead, Fischbach & Kovein, 1995). Young-Corbett and Nussbaum (2009) found that use of a wet sponge sanding method reduced respirable dust concentrations by 60 percent when compared to a block sander.

It is highly unlikely construction workers will wear respiratory protection to protect themselves from the crystalline silica for multiple hours during a shift. Most likely, they will take them off after application and continue working. Therefore, wet applications or wet sanding may be highly valuable in decreasing rates of exposure in construction workers aiming to reduce crystalline silica exposure. In the next sections, dry sanding and wet sanding will be discussed in order to understand the pros and cons of using either technique or why some construction workers will opt for one over the other.

1.2.3.2. Dry Sanding

Dry Sanding generates a lot of dust. This is because of the constant application of friction to the surface of the sheetrock. Since the sheetrock joint compound often contains crystalline silica, it disperses from the sheetrock as the construction worker dry sands. The particles released from the sanding action last for several hours. Research has shown exposure to crystalline and other potentially hazardous dust particles are higher from dry sanding than wet sanding. However, construction workers may use dry sanding because it is faster and involves less effort.

1.2.3.3. Wet Sanding

Wet sanding is common among construction workers and is used to smooth the surface of any sheetrock compound. Although the term is called sanding, it is not actually sanding at all. Instead, a rag or sponge is used to soften the sheetrock compound. This technique reduces chances for crystalline silica exposure greatly. However, it is not as fast as dry sanding and does not actually sand anything, but rather smooths surfaces. Wet sanding typically decreases exposure; nevertheless, it does not achieve the same results as dry sanding.

1.3. Scope and Objective

The scope of this paper will focus on past efforts performed to reduce silica exposure among construction workers, the effects silica exposure has on health, and the development of controls that may reduce silica exposure. These efforts developed an increased understanding of what techniques and approaches would help reduce the exposure and risk of the respirable crystalline silica.

1.3.1. Evaluate exposure to silica

Several techniques have been discussed that increase exposure to crystalline silica. Concrete drilling and sawing increase exposure to crystalline silica when performed dry. The same can be said of dry sanding sheetrock with joint compound. Even though published research points to the fact construction wet methods are safer than dry methods when compared to OSHA PEL, wet methods still pose an exposure hazard, as seen in the Company's sampling conducted in 2009 based on ACGIH TLV of 0.025 mg/m^3. Based on this sampling and observation done in

2009, construction workers' methods, habits, and experience play a pivotal role in their exposure.

1.3.2. Develop controls

In the last decade, many articles have been published to show the dangers of silica exposure and offer solutions. In an article about silica exposure and solution (University of Washington, 2015), it discusses the primary way to decrease crystalline silica exposure. "Water, ventilation, or isolation can reduce the dust getting into the air. Respirators can protect the worker from breathing the dust. Water is often the best option for dust control" (University of Washington, 2015). It works best when a person directs water spray right at the point of grinding or cutting. A fine mist is usually more effective than a water stream.

Cooper, Susi & Rempel (2012) reported success of control measures is probably high, and a sizable majority of the construction worker population uses them on a consistent basis. Nevertheless, both the questionnaire survey and exposure study demonstrated use of respiratory protection remains the most extensively used precautionary measure within the construction industry. Minimization through reduced dust dispersion or generation, isolation from the worker, capture or control may be a more efficient method of worker protection (Cooper, Susi & Rempel, 2012, p. D35).

The article by Rappaport et al., (2003) titled *Excessive Exposure to Silica in the US Construction Industry* estimated probabilities of overexposure in the range of 64.5% and 100% for crystalline silica and the range of 8.2% and 89.2% for dust. The data indicates silica exposures are clearly unacceptable within the US construction industry. Although engineering and administrative mediations are necessary to lessen overall air levels, the varied exposures among associates of each trade propose that controls should center, in part, upon the separate sites, equipment and activity involved. Effects of current controls as well as workplace features upon silica exposures were examined among laborers and operating engineers. Silica exposures were considerably decreased by “wet dust suppression (approximately 3-fold for laborers) and use of ventilated cabs (approximately 6-fold for operating engineers) and were significantly increased indoors (about 4-fold for laborers)” (Rappaport, 2003, p. 111).

Certain controls must be put in place in order to reduce occurrence of silica exposure. Employers have a responsibility to safeguard their workers from crystalline silica dust exposure when working on construction projects. Research shows when common construction work jobs involve the sanding, chipping, drilling, grinding, sawing, cutting, blasting, and sweeping of concrete/concrete products and are performed without utilizing dust controls, construction workers are exposed to airborne silica concentrations far above the industrial exposure limits. As mentioned before, dust control also includes the workers’ methods, habits, and experience on completing the task. Long-term/heavy short-term contact with airborne silica dust may cause severe lung disease.

Due to the major risk posed by respirable crystalline silica, it is important all workers involved in operations generating silica dust take precise action to guarantee that, as much as conceivable, a hazard is not formed. The employer can develop some controls based on the Figure 1, hierarchy of controls.

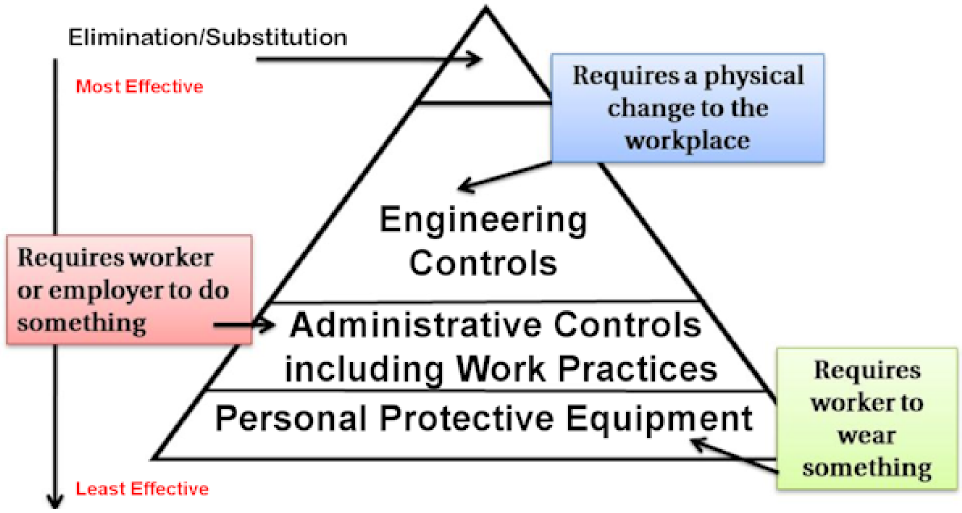

Figure 1 – Hierarchy of Controls (Controlling Exposures, n.d.)

In addition to the hierarchy of controls, the following practices should be implemented to increase worker protection:

- Guaranteeing materials (e.g., equipment, tools, personal protective equipment) as well as other resources like worker training materials are obligatory to fully maintain and implement the exposure control plan.

- Offering a job-specific exposure control plan (ECP) for every project, outlining and detailing the work practices and methods that will be adhered to on each site. Attentions will include
    - Accessibility and delivery of all the required equipment/tools
    - Nature and scope of work to be performed
    - Control methods used
    - Kind of respiratory protection if necessary
    - Coordination plan

- Directing a periodic evaluation of the efficacy of the ECP. This may include an evaluation of the available dust-control expertise to guarantee these are chosen and used when practical.
- Initiating sample of worker contact with concrete dust when non-standard work practices are present for which the control approaches to be used have not been proven to be sufficiently protective.
- Maintaining records of training, crew talks, fit-test results, and inspections of equipment, work methods/practices, and PPE.
- Organizing the work with the main contractor as well as other employers to guarantee a safe work environment.

2. Methodology and Implementation

Corrective actions instituted by the Company for added protection of contract workers included: 1) completing contractor personal air sampling that includes concrete sawing, concrete cutting and application, and dry/wet sanding sheetrock joint compound; 2) completing oversight observations of the tasks being sampled; 3) interpreting the air sampling results and correlating with oversight observations, i.e. work habits; 4) writing interim control procedures; and 5) using supporting literature to substantiate data and determine the impact of adopting the ACGIH TLV for occupational crystalline silica, respirable dust exposure.

2.1. Conducting Observation and Sampling

Personal breathing zone sampling for the Company's contractors was conducted for the following activities: concrete sawing/cutting and application, and dry/wet sanding sheetrock joint compound.

NIOSH method 7500 was utilized to collect and analyze the PBZ air monitoring samples. PCXR8 Universal Sample Pumps with 37-mm, 5.0 µm pore size polyvinyl chloride (PVC) filter cassette and aluminum cyclone were used to conduct this sampling. Each pump was pre/post-calibrated using a Bio DryCal DC-Lite –M calibrator at 2.5 liter per minute. The Bio DryCal DC-Lite –M calibrator optimum flow range is 100 ml/minute to 7 L/minute. Calibration and sampling media information is located in Appendix A: Air Monitoring Instrumentation/ Calibration Information.

2.1.1. Concrete Saw/Cutting Personal Air Monitoring

In March 2009, personal breathing zone (PBZ) air monitoring was conducted to evaluate exposure to RCSQ during concrete sawing/cutting activities where both workers wore MSA Ultra-twin 480259 full-face respirators with P-100 filters. A Meco M-20 Electric Slab Saw was operated by Worker #1 to cut the 8.5-inch deep floor slab (Figure 2). Eight floor areas were saw cut over the duration of work activities. Worker #2 cleaned up the concrete slurry produced by the concrete saw cutting using a wet shop vacuum. The duration of the concrete saw/cutting activities was approximately six hours and the duration of the air monitoring for both workers was five hours. Monitoring results are discussed in Section 4. Results.

Figure. 2 – Example of Concrete Saw Cutting in a Basement

2.1.2. Sheetrock Finishing Personal Air Monitoring

2.1.2.1. Sheetrock Finishing without Interim Controls

PBZ air monitoring was conducted in June and July of 2009 to evaluate exposure to RCSQ during sheetrock finishing (taping and mudding) activities. Workers were advised to wear a half-face respirator. Workers said their company policy is to only wear a respirator when dry sanding the sheetrock joint compound. They stated they would only work with the joint compound in a wet state. The workers applied USG Sheetrock All Purpose Joint Compound to the sheetrock walls using a trowel, which was a wet mud mixture. The MSDS for the joint compound indicates that it contains < 5% silica. Figure 3, Figure 4 and Figure 5 show examples of applying joint compound, dry sanding and wet sanding.

Contractor #1 workers only wet sanded the sheetrock joint compound when the joint compound had dried. Contractor #2 workers dry sanded for a short period with four-feet long handled wallboard sanders. During this short period, both workers wore N95 3M 8200 particulate respirators. Observation of workers' habits and practices were conducted during air monitoring. It was noted that Contractor #1 workers and Contractor #2, worker #1 were very sloppy with applying the joint compound, as seen by the excess joint compound on their clothing. Also noted during air monitoring for both contractors was that the areas were not kept clean throughout the day and dry sweeping was done at the end of each shift sampled.

Contractor #1 duration of the sheetrock finishing activities was approximately seven hours and 30 minutes, and the duration of the air monitoring for both workers was between six hours and six hours and 47 minutes. Contractor #2 duration of the sheetrock finishing activities was approximately seven hours and 30 minutes and the duration of the air monitoring for both workers was between six hours and six hours and 33 minutes.

2.1.2.2. Sheetrock Finishing with Interim Controls

Interim controls were developed by the Company's industrial hygienist. The controls were based on researched best practices and previous observations/sampling. They address activities not to conduct, e.g., no dry sweeping, dry sanding, etc. and activities to conduct, e.g., be as neat as possible applying joint compound, wet sanding, etc. to reduce respirable crystalline silica to as low as possible. PBZ air monitoring was conducted in August and September of 2009 to evaluate exposure to RCSQ during sheetrock finishing (taping and mudding) activities. Workers were advised to follow the interim controls listed in Table II. The workers applied USG Sheetrock All Purpose Joint Compound to the sheetrock walls using a trowel, which was a wet mud mixture. These interim controls were believed to reduce the overall exposure to workers. The MSDS for the joint compound indicates it contains < 5% silica.

Table I: Sheetrock Interim Controls

1. Keep the jobsite as clean as possible a. **No Dry Swiping** b. Use a Dry/Wet Vacuum with HEPA filtration c. When emptying Vacuum do not shake HEPA filter
2. Cutting drywall a. Use handsaws and/or utility knifes – Best Practice b. If using a router or rotozip use a vacuum attachment or place shaving cream on the cutline
3. When applying joint compound be as neat as possible a. Apply only what is needed b. Clean up excess joint compound when wet
4. Keep it off clothing – once it dries, it could become airborne
5. Sanding drywall mudded joints a. Wet sand joint compound layers when applying next layer of joint compound – Best Practice b. If dry sanding is required, use long handled (4') drywall sanders and wear a respirator

Contractors #2, #3 and #4 used control measures required by the Company's industrial hygienist to reduce their potential silica exposure during the sheetrock finishing activities. The control measures are required based on previous air monitoring events that documented exposures to silica (quartz) greater than the ACGIH TLV during sheetrock finishing activities.

The control measures employed by Contractors #2, #3 and #4 included applying only the joint compound that was needed; cleaning up excess joint compound when it was still wet; and keeping the joint compound off clothing. In addition to these controls, Contractors #2 and #3 also used a dry/wet vacuum with HEPA filtration when cleaning up.

Contractor #2 duration of sheetrock finishing activities was approximately 7 hours and 30 minutes and the duration of the air monitoring for Contractor #2's five employees was between 6 hours and 34 minutes and 7 hours and 15 minutes. Contractor #3 duration of the sheetrock finishing activities was approximately seven hours and 30 minutes and the duration of the air monitoring for both workers was between six hours and three minutes and seven hours and six minutes. Contractor #4 duration of the sheetrock finishing activities was approximately seven hours and the duration of the air monitoring for both workers was six hours and 44 minutes.

Figure 3 – Example of Applying Wet Joint Compound

Figure. 4 – Example of Dry Sanding

Figure. 5 – Example of Wet Sanding

3. Results

All RCSQ results were calculated using the two equations below:

Equation 1: Concentration of RCSQ Collected on Filter

$$C_{Silica\ [Quartz]} = \frac{\left(\mu g\ Silica\ [Quartz]\ \times\ 1000\,\frac{L}{m^3}\right)}{(minutes\ sampled\ \times liters\ per\ minute)}$$

Equation 2: 8 Hour TWA for RCSQ Exposure

$$TWA_{8\ Hour\ Silica\ [Quartz]} = \frac{\left(C_{Silica\ [Quartz]}\ mg/m^3 \times\ minutes\ sampled\right)}{480\ minutes}$$

The respirable crystalline silica sampling results are reported in Table III: PBZ Air Monitoring Results. The basement concrete saw/cutting Worker #1’s time weighted average (TWA) was 7.7 times the ACGIH TLV and Worker #2 was 6.1 times the ACGIH TLV. The concentrations measured during the concrete floor coring activities were within the assigned protection factor (APF) of 50 for the full-face respirator protection used by the workers.

The sheetrock finishing without the use of interim controls TWAs for Contractor #1 Worker #2 was 1.8 times the ACGIH TLV and 2.2 times the ACGIH TLV for Contractor #2 Worker #1. It was recommended workers from both contractors utilize half-face piece air purifying respiratory protection with P-100 cartridges prior to the start of the activity. The workers stated if they were dry sanding the dried joint compound they would wear respiratory protection; however, during application of wet joint compound they do not wear respiratory protection. Therefore, the workers did not wear respiratory protection during the wet application of joint compound.

The results of the sheetrock finishing incorporating interim controls PBZ air monitoring indicated that airborne exposures to silica (quartz) for Contractor # 2, #3 and #4 workers were all less than the ACGIH TLV. Contractor #2, #3 and #4 incorporated interim controls required by the Company as listed in Table I: Interim Controls.

Table II: PBZ Air Monitoring Results

Personnel	Activity Performed	Presence of Interim Controls	Date	Respirable Crystalline Silica TWA Results
Worker #1 Worker #2	Basement Concrete Saw/Cutting	No	March 2009	0.19261 mg/m^3 0.15184 mg/m^3
Contractor #1 Worker #1 Worker #2	Sheetrock Finishing	No	June 2009	< 0.00808 mg/m3 0.04393 mg/m3
Contractor #2 Worker #1 Worker #2	Sheetrock Finishing	No	July 2009	0.05378 mg/m3 < 0.00836 mg/m3
Contractor #2 Worker #3 Worker #2 Worker #4 Worker #5 Worker #6	Sheetrock Finishing	Yes	August 2009	< 0.00811 mg/m3 < 0.00813 mg/m3 < 0.00825 mg/m3 < 0.00803 mg/m3 < 0.00806 mg/m3
Contractor #3 Worker #1 Worker #2	Sheetrock Finishing	Yes	August 2009	< 0.00833 mg/m3 < 0.00821 mg/m3
Contractor #4 Worker #1 Worker #2	Sheetrock Finishing	Yes	September 2009	< 0.00805 mg/m3 < 0.00796 mg/m3

4. Conclusion

The observations and air monitoring at the Company's site quantified crystalline silica exposures associated with construction activities. The interim controls implemented at the site, which emphasizes worker practices/habits, engineering controls and PPE, revealed that properly implemented controls may result in RCSQ exposures below the ACGIH TLV of 0.025 mg/m^3 as illustrated in Figure 6.

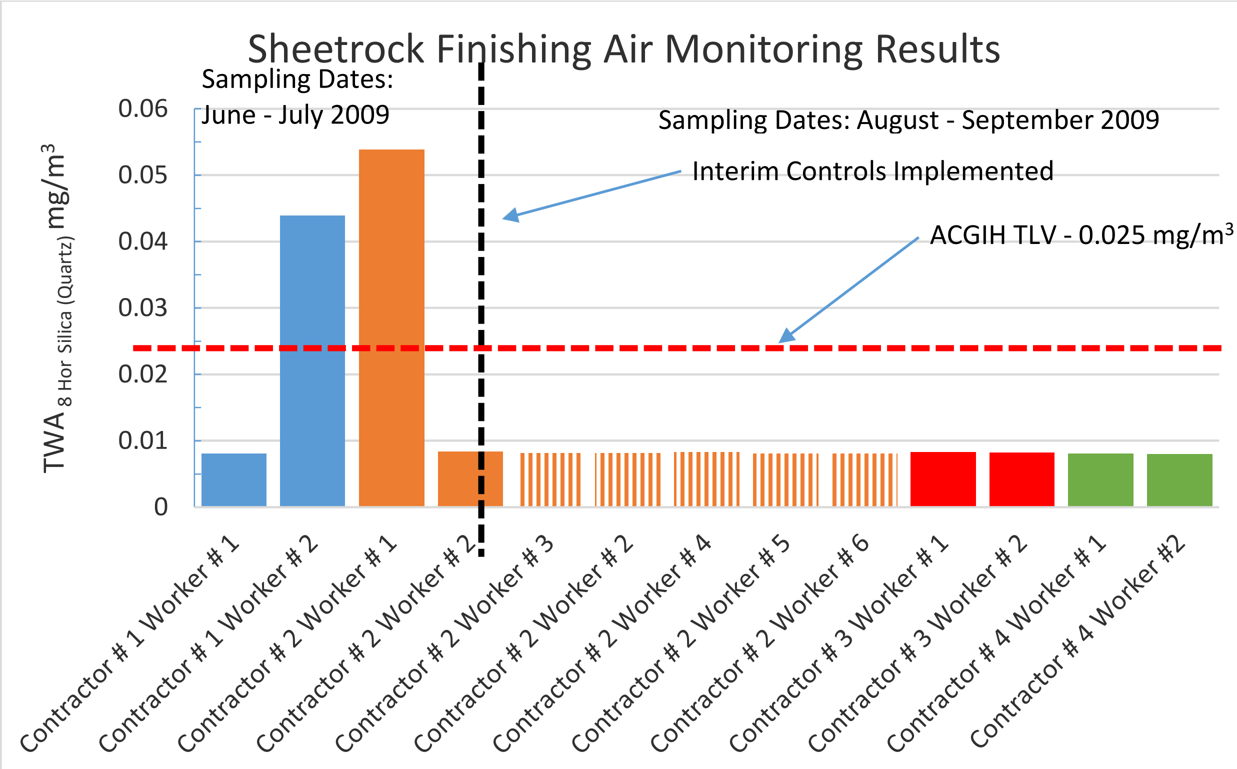

Figure 6: Sheetrock Finishing Air Monitoring Results – No Interim Controls vs. Interim Controls

The literature review provided past data and studies on controls and measures including long-term effects of crystalline silica exposure. Gaps in research show the need for more studies in crystalline silica exposure with implemented controls, as well as length of time crystalline silica exists within the air after performing a construction activity. Crystalline silica dust poses a significant threat and has posed it for over 200 years, affecting and killing millions of workers in trades including foundries, sandblasting, ceramics, jewelry manufacture, tunneling, brick making, and construction and mining.

More data is needed to grow awareness of the chronic and fatal conditions brought on by silica exposure, like silicosis, and chronic obstructive pulmonary disease. Without adequate research, cases of silica-related illnesses will increase, especially in underdeveloped countries. Protocols should follow both inclusion of PPE as well as tools that use water and ventilation.

Water clearly minimizes greatly the exposure to crystalline silica, as does ventilation, especially when combined together.

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Appendix A: Air Monitoring Instrumentation/Calibration Information

Table III: Air Monitoring Instrumentation/Calibration Information

	Instrument/Model	Serial Number	Calibration Due Date	Sampling Media
Sampling Date: July 2009				
Personnel	BIO DRYCAL DC-Lite-M	101547	3/10/2010	PVC 5.0 µm 37 mm with Aluminum Cyclone / Lot # 2961-7D6PASK-192-3
Contractor #1 Worker #1	SKC Airchek 224PCXR8 Personal Pump	707266	8/10/2009	
Contractor #1 Worker #2	SKC Airchek 224PCXR8 Personal Pump	707162	8/10/2009	
Contractor #2 Worker #1	SKC Airchek 224PCXR8 Personal Pump	671142	5/10/2010	
Contractor #2 Worker #2	SKC Airchek 224PCXR8 Personal Pump	707104	5/10/2010	
Sampling Date: August/September 2009				
Personnel	BIO DRYCAL DC-Lite-M	103073	6/10/2010	PVC 5.0 µm 37 mm with Aluminum Cyclone/Lot # 7660-7D9DASK-152-3
Contractor #2 Worker #3	SKC Airchek 224PCXR8 Personal Pump	707121	5/10/2010	
Contractor #2 Worker #2	SKC Airchek 224PCXR8 Personal Pump	707145	5/10/2010	
Contractor #2 Worker #4	SKC Airchek 224PCXR8 Personal Pump	531066	5/10/2010	
Contractor #2 Worker #5	SKC Airchek 224PCXR8 Personal Pump	707104	5/10/2010	
Contractor #2 Worker #6	SKC Airchek 224PCXR8 Personal Pump	707132	5/10/2010	
Contractor #3 Worker #1	SKC Airchek 224PCXR8 Personal Pump	707145	5/10/2010	
Contractor #3 Worker #2	SKC Airchek 224PCXR8 Personal Pump	531066	5/10/2010	
Contractor #4 Worker #1	SKC Airchek 224PCXR8 Personal Pump	707153	7/10/2010	
Contractor #4 Worker #2	SKC Airchek 224PCXR8 Personal Pump	707154	7/10/2010	